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Broca's Area and Marie's Quadrilateral Space in 21st-Century Aphasiology

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Background

Though Paul Broca and Pierre Marie both had a considerable impact on the study of aphasia, the contributions of the latter have received less attention in current models of language production. Pierre Marie (1906) believed that the speech production deficits associated with anterior lesions arose entirely from subcortical damage in the "quadrilateral space" (QS) that included the lenticular nucleus, the insula and deep, underlying white matter. He and his student, François Moutier (1908), presented numerous cases of Broca's aphasia without lesions to Broca's area or cases of Broca's area lesions without what we would call Broca's aphasia. Today, modern neuroimaging allows us to revisit the contributions of Broca's area and the QS in producing speech and language deficits. We have seen that Broca's aphasia can indeed arise from lesions to the QS while sparing Broca's area, and that chronic, persisting Broca's aphasia almost always requires the involvement of these deep structures.

The reason for the importance of the QS may well be because different brain structures as well as fiber pathways lie within this region and may each contribute, though in different ways, to the processing of speech and language. For example, one region that forms part of the QS is the superior tip of the precentral gyrus of the insula (SPGI) that has been implicated in the coordination of articulatory movements and the disorder of "apraxia of speech" (AOS; Dronkers, 1996). AOS is a hallmark of Broca's aphasia as nearly all patients with Broca's aphasia also have AOS. Thus, injury to the SPGI -- which falls within the QS -- has an effect on speech production and could be one reason why Marie observed speech deficits in his patients with lesions in this area.

The region encompassed by Marie's QS also contains important fiber pathways that link frontal regions with temporal lobe areas that support language. The arcuate fasciculusas and the inferior occipital-frontal fasciculus are two such tracts which pass through the QS as they connect inferior frontal regions with temporal lobe language areas (Turken & Dronkers, 2011). Disconnection of either of these major pathways could contribute to deficits in speech or language performance, which were undoubtedly also observed by both Marie and Broca in their patients with Broca's aphasia.

This presentation reviews the anatomy of Broca's area and the QS. We discuss the subregions and white matter pathways related to these areas. How each of these might contribute to the speech and language deficits observed in Broca's aphasia are also discussed.

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